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OF THE
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Some of the diagrams and portions of the text of this handbook have been taken, by permission, from Messrs. Barr & Stroud's handbooks.

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This book is corrected up to July, 1916. Any alterations which may be suggested should be forwarded direct to the Chief Inspector, Royal Arsenal, Woolwich.

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RANGE-FINDER, INFANTRY, No. 2 (Barr & Stroud).

CHAPTER I.

EQUIPMENT AND GENERAL DESCRIPTION.

In this Chapter the Mark III is taken as the standard type, and notes are made as to how the Marks I, I and II differ from it.*

1. The following comprise the equipment of the No. 2 Infantry range-finder :—

COMPONENTS.

- 1 Carrier.
- 1 Leather cover to protect eyepiece.
- 1 Rubber facepiece.
- 1 Web shoulder sling.
- 2 Dermatine rayshades (*with Mark I only*).

SEPARATE DEMANDABLE STORES.

- 1 "Case, No. 2 Infantry range-finder," with 2 testing-rods and screw-driver (with 4 blades).
- 1 "Cover, No. 2 Infantry range-finder," with wood box for sable cleaning brush.
- 1 "Frog, stand, Nos. 1 and 2 Infantry range-finders."
- 1 "Stand, Nos. 1 and 2 Infantry range-finders."
- Cleaning materials, viz., 1 piece of chamois leather, 1 piece of check union cloth and 1 sable brush.

The following can be packed in the wooden case :—

- 1 Range-finder.
- 1 Stand with frog.
- 2 Adjusting rods.
- 1 Screwdriver.

The canvas cover, with sling, takes the range-finder only, and is used for carrying it on the march.

On active service the wood case (with testing rods) is carried in the hind portion of the "G.S. limbered wagon for tools" in the first line transport; and the range-finder is carried by the range-taker in the canvas cover, the tripod stand being carried in its frog, which is attached to the waist-belt.

In barracks, the range-finder, stand and frog should be kept in the wood case, the canvas cover being strapped to the top of the case.

Plate I shows the case with the range-finder, stand, &c., packed in it. The following is a general description of the Mark III range-finder (see Plates II and III):—

The body of the range-finder consists of a tube, about 36 inches long, with canvas-covered rubber pads at each end, two eyepieces near the centre, and two folding handles.

A detachable rubber facepiece is attached to the tube, and surrounds the eyepieces.

Close to the right handle is the working head, by means of which coincidence is effected and ranges measured, as explained in Chapter II. Near the left handle is the astigmatiser lever, by means of which the astigmatismers can be brought into action.

Near the left end of the range-finder there is a revolving ring which protects two adjusting heads.

The ends of the body are of larger diameter than the remainder, and are fitted with revolving rings which protect the end windows.

Near the middle of the body, towards the front, is a circular window (with protecting cap) through which the range scale can be seen.

A shoulder strap is attached to the body, its position being regulated by fairways.

A carrier encircles the range-finder near the centre. It affords a means of attaching the range-finder to the tripod stand. The range-finder can be revolved in the carrier in such a way that the line of sight can be raised or lowered.

The weight of the instrument is about $9\frac{1}{2}$ lbs.

The Marks I, I* and II differ but slightly from the Mark III in external appearance. All these marks are described in detail in para. 7.

2. The "Case, No. 2 Infantry Range-finder," Mark II:—

The case is of wood, and is provided with fittings to hold the range-finder, stand in frog, screwdriver, and adjusting rods.

A pair of sockets are screwed to the case, inside the lid, to hold the adjusting rods in position when the range-finder is being tested and adjusted for zero (see paras. 25-28).

The adjusting rods are brass tubes about 24 inches long and one-third of an inch in diameter. One side of each is painted white, and the other black. Near the end of the rods is a feather which fits into a featherway in the sockets.

The dimensions of the case are:—

Length, 38 inches.

Width, $7\frac{1}{2}$ „

Depth, $5\frac{1}{2}$ „

Weight (without range-finder or stand, $12\frac{1}{2}$ lbs.

The Mark I case is generally similar to the Mark II but it is shallower, and the wood fittings differ slightly in shape. Two wooden blocks for taking the detachable rayshades are provided.

3. The "Cover, No. 2 Infantry Range-finder, Mark II," is made of waterproof canvas and is fitted with a web shoulder strap.

It is well padded internally, pockets being formed in the padding for cleaning materials (chamois leather and cotton cloth). A small cylindrical box, for taking a sable cleaning brush, is provided.

The cover is fastened up by means of straps, tabs and studs.

The Mark I Cover differs from the Mark II as follows:—The overlap of the edges is not so great, there is no means of keeping the ends closed, and no provision is made for taking cleaning materials or brush.

4. The "Stand, Nos. 1 and 2 Infantry Range-finders, Mark II," is made of aluminium alloy. It consists of a small tripod, at the top of which a head is pivoted. The head is provided with jaws and a clamping screw, by means of which it can be attached to the carrier of the range-finder. The pivot allows of the range-finder being traversed in any required direction. Its weight is about 1 lb.

The Mark I is generally similar to the above, but has slightly shorter legs.

5. The "Frog, Stand, Nos. 1 and 2 Infantry Range-finders," is of leather, and is provided with a loop for attachment to a waist belt.

CHAPTER II.—GENERAL PRINCIPLE.

6. If the length of one side and the value of any two angles of a triangle are known, the lengths of the other two sides can be calculated.

Thus, Fig. 1, in the triangle ADB, if the length AB is known, and the angles DAB, ADB can be measured, the lengths of the sides DA, DB can be calculated. Similarly in the triangle ABC, if the length AB is known and the angles BAC, ACB can be measured, the lengths of the sides CA, CB can be calculated.

If the length of AB remains fixed, and the angle BAD remains fixed also, then it is only necessary to measure the angle ADB in order to be

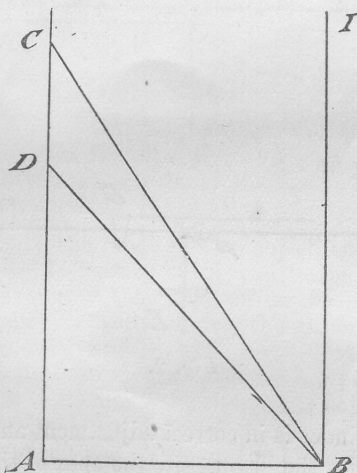


Fig. 1.

able to calculate the lengths of DA, DB. It will be seen from Fig. 1 that the longer AD becomes, the smaller will the angle ADB become, and that for any given length of AD there will be a corresponding value of the angle ADB.

If a line BI is drawn parallel to AC, it can be proved that the angle ADB is equal to the angle DBI, and the angle ACB is equal to the angle CBI.

Therefore, if we can measure the angle CBI, we can find the lengths of CA and CB from the triangle ABC. Similarly we can find the lengths of DA and DB from the triangle ABD if we can measure the angle DBI.

The infantry range-finder is an instrument which enables us to make practical use of the above mathematical facts for the purpose of measuring the range to a distant object. The instrument itself forms the side AB and the distant object is the point C of the triangle ABC, the two sides AC, BC being formed by the rays of light from the object to the two ends of the range-finder.

The instrument is so constructed that (when once it has been adjusted) the angle BAC remains constant, and the length of the instrument is, of course, fixed. The angle CBI is measured by moving a "deflecting prism" to which the range scale is attached, along the right half of the range-finder. The different positions of the deflecting prism correspond to various values of the angle CBI, and therefore, as explained above, to various lengths of CB or CA.

It is therefore possible to graduate the range scale in yards, and so avoid all calculations. Means are provided by which the "lines of sight"* of the two telescopes can be set parallel to one another, *i.e.*, referring to Fig. 1, the lines of sight of the two telescopes would be AC and BI respectively. By moving the deflecting prism the line of sight of the right hand telescope can be inclined gradually to the left (*i.e.*, in the direction BC or BD). In this way the angles IBC, IBD can be measured and thus the ranges CA or DA are found.

Fig. 2 is a typical diagram of the range-finder showing the left prism A, the right prism B, the deflecting prism D (with range scale attached), the central prism P, the eye-piece E, and the object glasses FF.

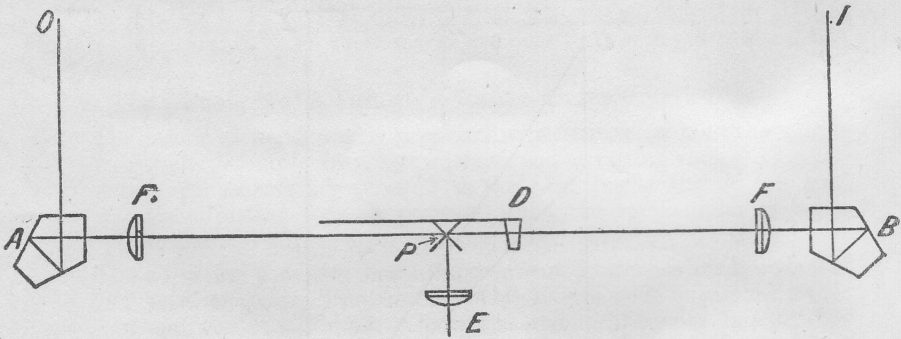


Fig. 2.

When the range-finder is in correct adjustment and the range scale is set to infinity (*i.e.*, with the * opposite the apex of the reader) the lines of sight of the two telescopes are EPAO and EPBI, and these, as they leave the instrument, are parallel to one another (*i.e.*, AO and BI are parallel).

* The words "line of sight" are adopted as a convenient expression to denote the path of a ray of light from a distant point which enters either the right or left telescope in such a way as to produce an image of that point in the centre of the field of view—or, more correctly, the path of the central ray of the pencil of rays which produces that image.

Or, if we consider it as starting from the eye, it is the line which passes through the centre of the eye lens and the centre of the field of view and passes out through the right or left telescope—its direction on leaving the instrument depending, of course, on the position of the deflecting prism in the case of the right-hand telescope and of the adjusting prism in the case of the left telescope.

If the deflecting prism is moved until the range scale is reading, say, 800 yards, the line of sight of the right telescope will be deflected as shown in Fig. 3, and the lines AO and BC will meet at a point 800 yards from the range-finder.

Similarly, if the range scale be set to any other range—*e.g.*, 500 or 1,000 yards—the line of sight will be deflected by a corresponding amount and the line BC will meet the line AO at a point 500 or 1,000 yards from the instrument.

The range-finder consists of two telescopes with only one eyepiece (the second eyepiece on the instrument is only for reading the range scale), and is so arranged that an observer looking into the right eyepiece, sees two images of the object at which the range-finder is pointed, one above the other, separated by a fine line called the “dividing line.” The image seen below the dividing line is formed by rays of light which enter the right-hand end of the instrument, and is erect (*i.e.*, the right way up). The image seen above the dividing line is formed by rays of light which enter at the left-hand end of the instrument, and is inverted (*i.e.*, upside down).

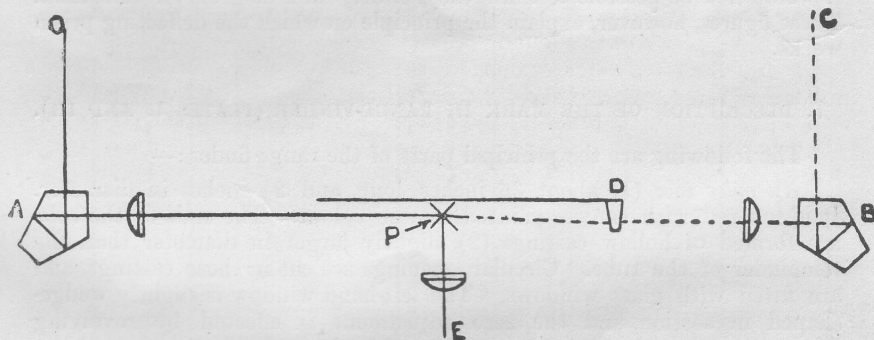


Fig. 3.

In order to measure the range of the object, the working head near the right handle must be turned until one image is exactly vertically above the other; the range is then read off on the range scale. This act of bringing one image vertically above the other is called “making coincidence.”

Turning the working head moves a “deflecting prism” (and the range scale which is attached to it) along the right-hand half of the range-finder. This deflecting prism bends (or deflects) the rays coming from the right-hand end of the instrument, and so moves the lower image across the field of view. When the lower image is vertically below the upper the range scale shows the range of the object.

When the range-finder is turned so that the object is seen in the centre of the upper half of the field, the rays of light from the distant object enter the left window, as shown by the continuous line (Fig. 3), are reflected at right angles by the left prism, pass through the left objective, and are reflected outwards through the eyepiece by the centre combination of prisms.

The rays from the same object enter the right window, as shown by the dotted lines, are reflected at right angles by the right prism through the right objective, and pass through the deflecting prism, which bends them as shown in the figure, and are reflected outwards through the eyepiece by the centre combination of prisms.

used when the ranges of moving targets are being taken, a second observer being detailed for reading them.

By a simple arrangement of prisms the scale when seen through the left eyepiece is made to appear vertical. This facilitates reading it.

Figs. 7 and 8 show the scale as seen through the eyepiece and through the front scale windows respectively. Beyond the highest range on the scale the infinity line, marked with a star (*), is engraved.

In order to read the scale at night a light must be placed opposite the front scale window.

Beneath the eyepieces is the carrier, by means of which the range-finder is attached to the stand. The carrier allows of the range-finder being elevated and depressed. Attached to the carrier is a leather cover, which is buttoned over the eyepieces when the range-finder is not in use.

Beneath the range-finder to the right and left of the eyepieces are two folding handles (10), by means of which the range-finder is manipulated when fixed to the stand, or held when no stand is used.



Fig. 7.

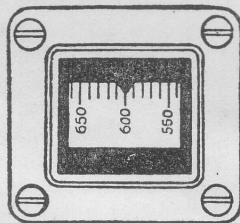


Fig. 8.

Near the right handle is the working head (11), by means of which coincidence is effected. It can be revolved by the thumb and forefinger of the right-hand whilst the remainder of the hand grips the handle.

Near the left handle is the astigmatism lever (12). When this is pushed up towards the main tube a point of light is seen (in each half of the field of view) as a bright line, which extends for about a quarter of the height of the field of view.

When the astigmatism is no longer required the lever must be drawn away from the tube.

A web shoulder sling is attached to the tube by means of leather straps and fairways.

End caps (13), made of gun-metal, screw on to the ends of the outer tube. Each is fitted with a pad formed of a rubber ring enclosed in canvas or leather. A small locking piece (14), kept in position by a screw, prevents a cap being unscrewed until it is removed.

See Plate IV. for the following internal parts.

The end prisms or pentagonals are of the section shown in Fig. 9. The two sides BC, DE are silvered and inclined to one another at 45 degrees. Rays of light coming from any direction, provided that they

are in the same plane as the section, entering the prism through the face AB and reflected by the two silvered surfaces, will emerge from the face AE at right angles to their line of entry. The prisms can, therefore, be mounted in the outer tube without risk of the direction of rays reflected by the prisms being altered if the tube becomes slightly bent.

The prisms (15) are mounted on metal plates (16) having projections which fit accurately into grooves in the end castings. The prisms can be adjusted with reference to the plate. The adjustment of the right prism must on no account be tampered with. The adjustment of the left prism is effected by means of the halving adjusting head, which when turned raises or lowers the line of sight through the prism. When the end caps are screwed home they press firmly against the prism mounts.

The inner frame (17) is a steel tube of square section, and is supported in the outer tube at three points.

Near each end is an object glass (18). Near the centre is the centre prism combination (19) which receives rays of light from the end prisms. The rays of light from the left prism form above the dividing

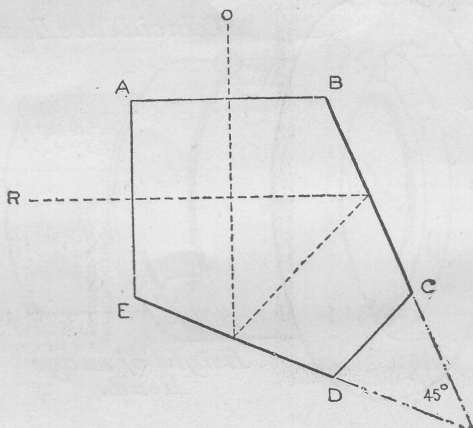


Fig. 9.

line an inverted image of the object laid on, and those from the right prism an erect image of the object, in the lower field. These images are formed in a plane at right angles to the right eyepiece, through which they can be seen.

Between two of the prisms in this combination is the dividing line, formed by the edge of a silvered surface. The two surfaces being balsamed together, no dust, &c., can get on to the dividing line. This effectually prevents any dust or dirt being seen in focus when the instrument is in use.

The deflecting prism and ivory range scale are attached to one another; the deflecting prism being on the right. They can be moved along the inside of the inner frame by means of a rack and pinion; the spindle (20) upon which the pinion is mounted projecting through the frame. The working head (11) outside the tube is keyed on to this spindle. A simple prism combination makes the scale appear to move upwards, instead of sideways, in front of the left eyepiece. The back of the range scale (which is graduated on both sides) can be seen through the front range scale window which consists of a magnifying lens.

The astigmatism lenses are hinged near the ends of the inner frame. They are put in or out of action by means of wires connected to a small lever (22), a fork in which gears with the astigmatism lever (12) outside the outer tube, near the left handle.

Fig. 10 shows the arrangement of the adjusting heads, both of them being uncovered.

The revolving ring which covers the adjusting heads cannot be moved independently of the revolving ring which covers the end window until a small spring catch (not shown in the figure) has been released.

The *height of image adjusting head* is a milled wheel on the under side of the instrument; it is covered, when not in use, by a revolving ring.

The *zero or coincidence adjusting head* is placed on the upper side of the instrument and is covered by a sliding plate. When this plate is pushed to the left the adjusting head springs out. After the adjustment has been made the adjusting head must be pressed down, care being taken not to turn it while doing so, and the sliding plate must then be pulled over it. The adjusting head must be kept clean, and if necessary should be oiled from time to time, but only a very little oil should be used, one or two drops at most.

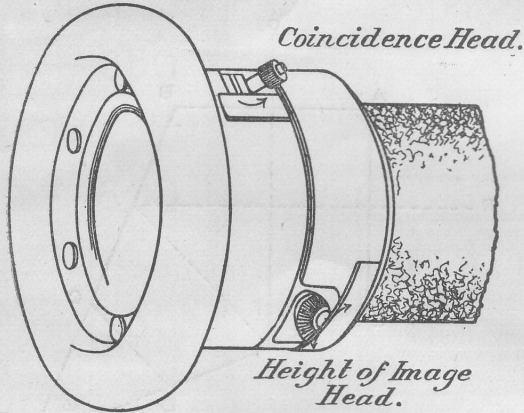


Fig. 10.

The left end window, which revolves when the coincidence adjusting head is turned, has a scale marked round its edge. This scale shows how much the end window has been turned in making an adjustment, and the method of using it is explained on p. 28.

The following are the principal particulars of the optical construction of the range-finder:—

Magnification	14 diameters.
Field of view	Horizontal	2° 50'
	Vertical	{ upper field		...	50'
		{ lower field		...	85'

The Marks I, I* and II instruments are generally similar to the Mark III. The principal points of difference being:—

Mark I—

- (1) The body is covered with leather instead of canvas.
- (2) The front scale window does not magnify, and has no hinged protecting cover.
- (3) Detachable rubber rayshades are provided.

- (4) *The supporting bands which carry the inner frame, and to which the handles are attached, are made of aluminium instead of gunmetal.*
- (5) *The eyepieces are not fitted with ebonite eyecaps.*
- (6) *The eyepieces are inclined downwards at 45 degs. instead of 60 degs.*
- (7) *The astigmatiser lenses are mounted between the object glasses and the centre prism combination. This necessitates refocussing when they are put in action.*
- (8) *The focussing lever of the right eyepiece is of different design.*
- (9) *Short fixed handles instead of folding ones are provided.*
- (10) *The end prisms are mounted in a different way. They are fully described in para. 55.*
- (11) *The adjusting heads are differently arranged, and there is no scale on the left-hand window.*

Mark I*—

The Mark I differs from the Mark I only in having the supporting bands (see (4) above) made of gunmetal.*

Mark II—

The Mark II differs from the Mark III in the details numbered 6 to 11 mentioned above. It is similar to the Mark III in the details numbered 1 to 5.

CHAPTER III.—RANGE TAKING.

1. GENERAL INSTRUCTIONS.

8. In selecting a range-taker the following points should be observed :—

He should be a N.C.O., but not a section leader, be strong, active and intelligent; have good eyesight; be a good and quick writer, and have a knowledge of the military vocabulary.

Duties of a Range-taker.

(i) *In attack.*—To attend preliminary reconnaissance and prepare range cards. During attack, check ranges, take any others required, and observe. If a position is seized, prepare range cards at once for its defence.

(ii) *In Defence.*—Prepare range cards for each trench and have them fastened up in prominent places. If defence is for a long period, inspect daily and replace or repair cards where necessary.

9. The following instructions will be observed whenever ranges are being taken, in order to habituate men to correct methods :—

(i) Rapidity and scrupulous accuracy are essential to successful range taking. These are only attained by progressive and careful training, which must ensure that accuracy is never sacrificed to rapidity, the latter being gradually attained as proficiency in the former increases.

(ii) The stand should always be used when possible. When this cannot be done, endeavour should be made to support the instrument otherwise.

(iii) The right eyepiece should always be focussed very carefully, and its position for correct focus should be remembered.

(iv) Before using the range-finder, both the height of image and zero should invariably be tested, and adjusted if necessary. If there is only a slight error, readings may be taken from a position on the reader (see para. 28).

(v) An error in the height of image (abbreviated as H.I.) should be corrected as soon as possible (see para. 23).

(vi) Coincidence should always be made in the centre of the field of view, and, if possible, with the dividing line at right angles to the object observed.

(vii) The thinnest and best-defined part of an object should be selected to range on.

(viii) For all long ranges, if time permits, the mean of four readings should be taken. In any case, two readings should be taken, finishing one by turning the working head to the right, and one by turning it to the left.

(ix) If the right eye-piece is provided with coloured glasses, they should be used in misty or bright weather.

(x) When the range-finder is not in use, the revolving end rings should be turned round, so as to cover the windows opposite the end prisms, and the eyepieces should be covered by the leather cap.

(xi) If the stand is used, it is not necessary to take it off when advancing. By loosening the thumb screw it can be made to lie nearly parallel with the instrument, and can be clamped in that position.

(xii) The range-taker should make the best use of ground and cover to conceal his movements and actions; the sky line should be avoided.

(xiii) When it can be avoided, ranges should not be taken from the actual position which it is intended to occupy with troops, so as not to disclose it should the enemy detect the presence of a range-taker.

(xiv) The range-finder is on no account to be taken to pieces, or any part removed, except by a fully-qualified officer or trained artificer (see para. 55), and then only to the extent mentioned in paras. 54 and 55. Minor repairs that may be carried out by an armourer are detailed in para. 54.

2. SYSTEM OF INSTRUCTION.

10. Short lectures, explanatory of, and corresponding to, the stage of practical instruction reached, should be given from time to time. These should include the object and method of ranging, the necessity for accuracy and rapidity, the importance of concealment, the position of the range-taker, the selection of ranging marks, the importance of a clear and concise written description of the object, the use of range cards and key ranges, the theory of the range-finder, the care and cleaning of the range-finder, the methods of testing and adjusting, &c.

Instruction should be progressive, and may be divided into (a) elementary, and (b) advanced. It is essential that every detail of the elementary stage should be thoroughly known before the advanced stage is begun.

11. It is important that a sequence of instruction should be followed throughout the elementary stage. In the following pages a suitable sequence is given, which should be followed.

ELEMENTARY STAGE.

(1) *Unpacking and setting up the Instrument.*

12. Place the wood case flat on the ground, unstrap it, press in the catch and raise the cover. Note how the articles lie in the case. Remove the stand from its frog, and lay it on the ground. Lift the range-finder from the case, holding it centrally; attach the stand to the carrier at right angles to the instrument, holding the latter under the left arm, the radiating corrugations to face one another; clamp firmly; open the legs of the stand, and place the latter on the ground. Release the tongues of the leather cap and revolve the range-finder until the eyepieces are at an

angle of 45 degrees (with the Mark I or II) or 60 degrees (with the Mark III) to the horizontal plane, or the handles are directed towards the ground. Turn the revolving end rings until the end windows are completely exposed. See that the adjusting heads at the left revolving end ring are not exposed.

To unpack and set up from the canvas cover, remove the stand from the frog, lay the range-finder and cover on the ground, unstrap the cover and remove the range-finder then set up as detailed above. Sling the empty cover over the shoulder.

To fix the rayshades (Mark I) engage the top hole on the stud provided for it; then stretch the rubber, and slip the lower hole over its stud.

(2) *Repacking.*

13. *Into wood case.*—Remove the ray shades, if any, and place them in the wood case. See that the focussing lever is to the rear; rotate the range-finder until the eyepieces are uppermost, cover the rubber facepiece with the leather cap, and fasten the two tongues of the latter on the studs. Turn the revolving end rings to the rear, and see that the adjusting heads are covered; raise the range-finder and hold it under the left arm, close the legs of the stand and remove the stand.

Place the range-finder in its case, facepiece to the front. Replace the stand in its frog, thumbscrew to one side, and place it in the correct position in the case. Shut down the lid, taking care that nothing interferes with its closing, lay the canvas cover on the lid and fasten the straps of the wood case over it.

In canvas cover.—Proceed as detailed above as far as removing the stand from the range-finder; place the range-finder in the case with the carrier in the leather pocket; place the rayshades, if any, one on either side of the leather cap (see Plate V), and strap the case. Replace the stand in its frog.

It is advisable to carry the range-finder slung over one shoulder in preference to carrying it across the back.

(3) *Focussing of the Eyepiece.*

14. A good focus of the eyepiece is essential for an accurate coincidence. To focus the eyepiece, direct the range-finder at the sky, and gradually turn the focussing lever until a perfect definition of the dividing line is obtained. This done, a constant focus is, as a rule, obtained for all ranges.

The range-taker should remember the position of the focussing lever required for a perfect focus. In the Mark III the reading on the diopter scale should be noted. This will tend towards rapidity in ranging subsequently.

If the astigmatic glasses are used a different focus from that normally used will be required, with the Marks I and II, but not with the Mark III. When testing the instrument at night, or when ranging on a light, it will not be possible to focus on the dividing line; therefore the object in these cases must be focussed. This applies also when carrying out elementary instruction in confined spaces (see para. 50).

(4) *How to hold the Instrument.*

15. The lying position, using the stand, should always be adopted in the elementary stage. The range-finder will be held by the handles with both hands without any constraint, and without any downward pressure on to the stand.

The forefinger and thumb of the right hand will be free to manipulate the working head. The elbows must rest on the ground; the face will rest against the facepiece, but must not be pressed into it, as the heat of the face, if brought too close to the eyepiece, will cause a mistiness of the lenses (see Plate VI).

(5) *Reading the Scale.*

16. The scale will be read through the left eyepiece by the left eye; it can also be read by a second observer through the scale window on the front of the range-finder.

Ranges are normally read from the apex of the reader. The graduations on the scale are as follows:—

From	250 yards to	1,000 yards,	the divisions are each	10 yds.
"	1,000	"	1,500	"
"	1,500	"	2,000	"
"	2,000	"	5,000	"
"	5,000	"	10,000	"
"	10,000	"	20,000	"

The infinity mark is indicated on the scale thus:—†

The range-taker should be taught to read in single yards up to 500 yards, in multiples of 5 yards from 500 to 1,000 yards, in multiples of 10 yards from 1,000 to 2,000 yards.

Practice should be given in reading from other parts of the reader (see para. 28) as well as from the apex of the reader.

(6) *Care and Cleaning of the Instrument.*

17. It must be realized that, though the range-finder is constructed to stand very much rougher usage than most scientific instruments are subjected to, it should be regarded as a delicate optical instrument, and should be treated with as much care as is given to a telescope. Every possible precaution should therefore be taken to preserve the range-finder from damage, and it should not be thrown on the ground or subjected to any avoidable shock.

The range-finder should be protected as much as possible in wet weather. When rain ceases, or operations are over, the outside of the range-finder should be wiped over with a rag. The range-finder must not be left in a damp canvas cover or wood case, neither must it be put away wet into the canvas cover or wood case. When cleaning the exterior of the range-finder, attention must be paid to the crevices near the adjusting heads, the working head, and the astigmatiser lever, and also to the eyepieces; a feather may be used for the purpose. The rubber facepiece will be cleaned occasionally by removing it and washing it with soap and water. It must be carefully dried previous to its being refitted to the range-finder.

The end windows, scale window, and eyepieces should be wiped with a clean soft cloth or piece of chamois leather, specially kept for the purpose.

The metal work may be rubbed down with a dry cloth; cleaning paste must not be used on any part of the instrument.

The metal work should be wiped periodically with a *very* slightly oiled rag, and particularly if it has a blotchy appearance. No trace of oil must be left on parts from which it might spread to the windows or lenses. Rangoon oil or vaseline, only, may be used.

If the revolving rings to which the carrier is attached become stiff they should be lubricated with a little oil or vaseline, which can be introduced by removing the centre screw on either side. After oiling,

replace the screws. The working head may be also slightly lubricated with pure vaseline when necessary. The metal work under the revolving end bands should be wiped as far as possible with a dry rag.

The greatest care must be taken not to allow any oil or grease to get on to any of the windows, lenses, or prisms, nor should they be touched with the fingers. It will be found that the eyepiece lenses frequently become misty when ranging. On no account is the lens to be cleared by the thumb or finger, but a handkerchief should be used for the purpose.

Moisture may get into the instrument and condense on the surfaces of the prisms or lenses, causing the inside of the range-finder to appear misty, and making it impossible to use the instrument. If this happens, remove the end caps as described in paragraph 55, and place the range-finder in a dry warm room or in the open air, if the day is dry and fine, and allow dry air to circulate through the instrument. A piece of muslin or handkerchief must be placed over each end of the range-finder to prevent dust from entering. If this fails to remove the moisture, the inner tube may be taken out and the various parts cleaned.

Only a qualified officer* or trained artificer† is permitted to remove the end caps, &c., for the above purpose.

It should very rarely be necessary to strip the range-finder, as described in para. 55 for cleaning purposes.

The internal optical parts should be lightly brushed over with a soft camel hair or sable brush to remove grit and dust, and should then be carefully wiped with a clean silk handkerchief or a piece of perfectly clean chamois leather.

The faces of prisms and lenses should be *very lightly* rubbed, otherwise the surfaces may be damaged. This refers most particularly to the separating prism in the centre prism combination (see 19 in Plate IV).

Any dirt that appears well defined in the field of view must lie on the separating prism faces, which alone are in the focus of the eyepiece. In the Mark III these are enclosed in such a way that dirt cannot reach them. Ill-defined spots in the field may be due to dirt on the outer face of the separating prism, or on the face of the centre combination of prisms opposite the separating prism faces. Dirt on other optical parts of the instrument will not be in focus and cannot therefore be seen when looking into the eyepiece, and will only result in a general darkening of the field of view. During temporary pauses in ranging, the range-finder should be protected by revolving the end rings, and covering the facepiece with the leather cap.

It is forbidden to look through the range-finder at the sun, even with the aid of the coloured glasses. If this is done, the range-finder will be permanently damaged, and the observer's eyesight also will be affected.

The straps and slings provided for carrying purposes should be frequently examined for signs of wear, and any defect should receive attention at once.

(7) *How to pick up an Object.*

18. Notice any prominent objects adjacent to the object to which the range is required, then look over the range-finder above the eyepieces at these objects to get a rough direction. Look through the right eyepiece and get the required object in the centre of the lower field of view by the aid of the prominent objects noticed in the first instance, the range-finder being revolved on its stand if necessary, or rotated in its bearing rings.

* *Qualified officer, i.e., one qualified at a Barr and Stroud range-taking course at Hythe.*

† *Trained artificer, i.e., an armourer qualified in small repairs at Woolwich.*

A duplicate representation of the image seen in the lower field of view will be presented inverted in the upper field of view.

Much practice is required in picking up an object quickly.

Care must be taken not to breathe into the facepiece when obtaining the rough direction.

(8) *How to make a Coincidence.*

19. As has already been explained, when the range-finder is pointed at any object, the observer looking into the right eyepiece sees two images of the object, the lower image being erect and the upper image inverted. To measure the range of the object, the working head near the right handle must be turned until some well-defined point on the image seen in the lower half of the field lies immediately below the same point on the image seen in the upper half of the field. The range is then read on the scale. The accuracy with which the range is measured depends on the accuracy of the coincidence, and it is important that range-takers should realize that a very small error of coincidence may mean a very large error in the range obtained. They must therefore be taught to make coincidence deliberately and carefully, and to be certain that the coincidence is as perfect as possible before they read off the range.

Figs. 4A and 5A show how a flagstaff is seen in the field of view, when coincidence has not been obtained.

Movement of the working head brings the two images together and, if the point with which coincidence is to be made does not touch the dividing line (see Fig. 11) the instrument must be rotated downwards till it does touch, in order to secure a perfect coincidence.

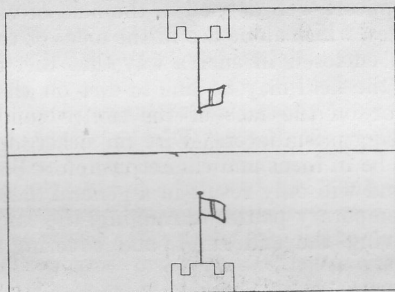


Fig. 11.

Fig. 6A shows the appearance in the field when coincidence has been obtained.

The coincidence is correct if the two images look like one continuous pole without any break in the continuity of its sides.

By still further depressing the range-finder, the images will appear as in Figs. 12 and 13.

Fig. 14 shows a bad coincidence, which would cause a serious error, especially at the longer ranges. It is very important that this should be thoroughly realized, and the instructor should not be content with anything but the best coincidence possible. If there were no flagstaff on the tower, coincidence could equally well be made on an edge of the tower (see Fig. 15).

In the same way coincidence can be made on objects which have no straight regular outlines, such as bushes, branches of trees, tufts of grass, men, or horses, for, by gradually rotating the range-finder and so

bringing the images closer together, and by moving the working head, coincidence can be obtained by bringing the chosen point of the object in the lower half of the field exactly under the same point of the object in the upper half. (See Figs. 16, 17, 18A, and 18B.)

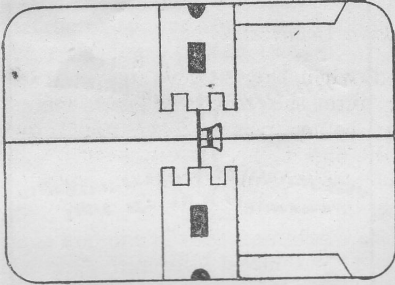


Fig. 12.

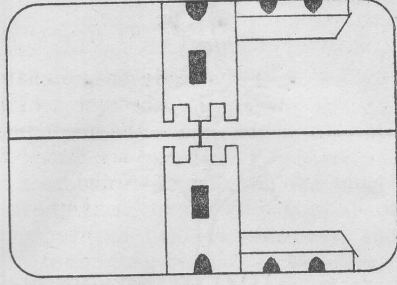


Fig. 13.

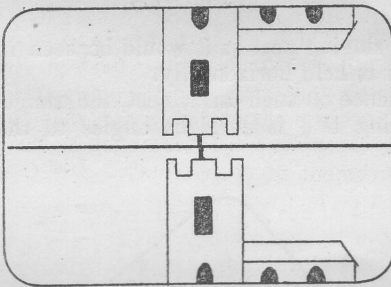


Fig. 14.

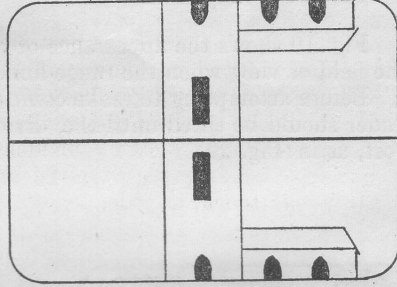


Fig. 15.

The direction in which the working head should be turned must be remembered, *e.g.*, if the upper image is on the right of the lower image (see Fig. 4A), the working head will be pushed with the forefinger; if the

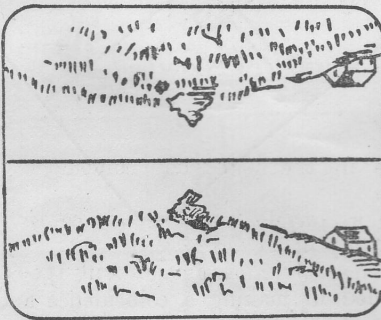


Fig. 16.

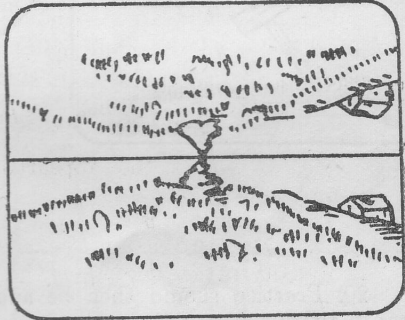


Fig. 17.

upper image is on the left of the lower image (see Fig. 5A), the working head will be pulled with the forefinger.

The correct turning of the working head should become automatic by practice.

The range-finder should always be held in such a way that the object on which coincidence is being made is in the centre of the field of view and is at right angles to the dividing line. If

the object which is being ranged upon is not vertical, the range-finder must be tilted to one side or the other until the dividing line is at right angles to it.

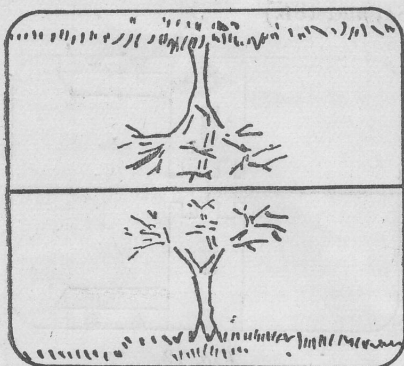


Fig. 18A.

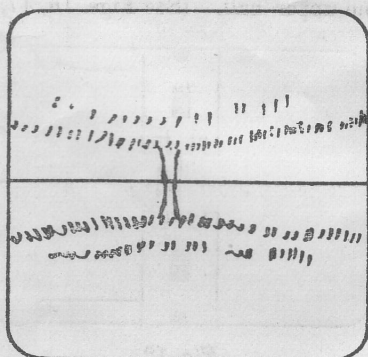


Fig. 18B.

Fig. 19 shows the appearance of a sloping post as it would be seen in the field of view when the range-finder is held horizontally.

Before attempting to make coincidence on such an object, the range-finder should be tilted until the dividing line is at right angles to the post, as in Fig. 20.

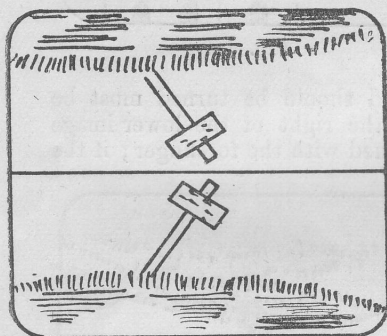


Fig. 19.

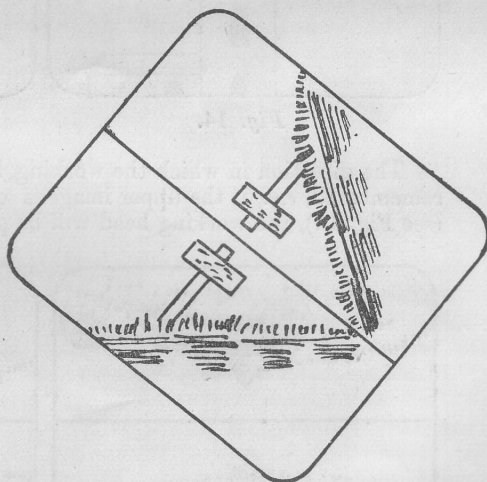


Fig. 20.

20. Practice should then be afforded in making a coincidence and reading the scale. Four readings at least should be taken, and the mean of the readings mentally worked out.

For the first and third of these, coincidences should be obtained as already explained. For the second and fourth, the erect image should be brought under the inverted from the opposite direction, thus affording a check.

The objects selected should not be at a greater distance than about 800 yards.

Coincidence should be obtained quickly. Dwelling on a coincidence

tires the eye. Should the eye tire in the early instruction, it should be momentarily rested.

In the elementary instruction it is advisable that the scale should be rendered invisible to the observer while coincidence is actually being made. This can be effected by covering the left eyepiece by a handkerchief, the latter being kept in position by the rubber facepiece. This enables the instructor to read the scale through the scale window, and thus ascertain the consistency of the readings. The scale can also be made invisible to the observer by closing the cover over the front scale window in range-finders of the latest pattern.

3. ADJUSTMENTS.

In the preceding pages it has been assumed that when the two images of an object are brought into coincidence in the field of view, exactly the same amount of each appears in each half of the field of view, and that the range indicated by the scale represents the true distance of the object ; but the range-finder may be out of adjustment in one or both of these respects. Two tests are therefore provided for checking the range-finder in these respects, viz. :—

The height of image test.
The zero test.

If either of these tests shows the range-finder to be incorrect, means are provided by which the error may be corrected.

To Test and Adjust the Height of Image.

21. When the images are in the field of view, and the height of image is correct the inverted image of any object should be the same distance vertically above the dividing line as the erect image is below it, and if the range-finder is gradually depressed, so as to make the two images approach the dividing line, they should touch it simultaneously.

An error in the height of image is caused by—

1. Any tilting movement of the end prisms.
2. Any movement of the inner frame in the vertical plane.
3. Any warping of the inner frame.

Figs. 4A, 5A, 6A, 11, 14, 15, 16, 17, 18, 19, and 20 show correct height of image.

If one image is touching the dividing line, and the other is either above or below it, the height of image is incorrect.

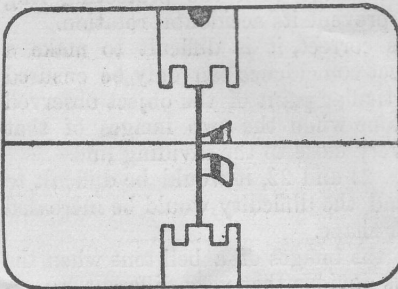


Fig. 21.

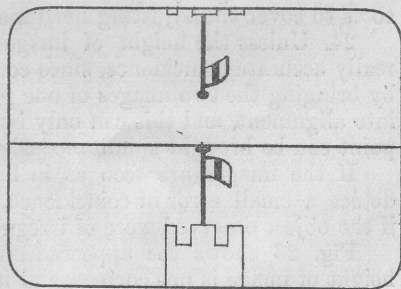


Fig. 22.

Figs. 21 and 22 show incorrect height of image. Fig. 21 shows an error of the upper image being *too low* ; Fig. 22 that of the upper image being *too high*.

To Test the Height of Image.

22. Almost any natural object which can be clearly seen can be used. If, when the range-finder is slowly rotated, a spot in the erect image touches the dividing line exactly at the same time as the same spot on the inverted image, the height of image is correct. Thus, in Fig. 6A, the height of image could be tested by bringing together the images of the top of the flagstaff, or of the top of the tower, or of the top of the window in the tower; in Fig. 16 the bush, or the cottage on the skyline, or the skyline itself can be used.

To Adjust the Height of Image.

23. If the images do not appear as in the preceding paragraph, the height of image is incorrect and must be adjusted.

The range-finder should be mounted on its stand, or on some support, so that it can be held quite steady, and the eyepiece must be carefully focussed.

Turn the ring near the left end of the range-finder until the "height of image" adjusting head is uncovered.

Hold the range-finder with the left hand encircling the left end pad; then direct the range-finder so that the erect image of the object is just touching the dividing line, and the inverted image is above or below the dividing line, and bring the images roughly into coincidence by means of the working head (see Fig. 22).

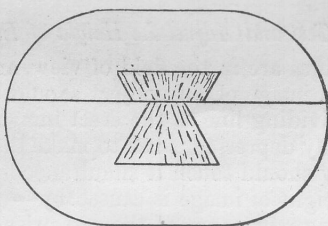


Fig. 23.

If the inverted image is too high (see Fig. 22), rotate the adjusting head towards you with the forefinger of the left hand; if the inverted image is too low (see Fig. 23) rotate the adjusting head from you until the same point on both images touches the dividing line simultaneously.

After having adjusted the height of image, turn the protecting ring so as to cover the adjusting head and prevent its accidental rotation.

24. Unless the height of image is correct, it is difficult to make a really accurate coincidence, since correct coincidence can only be ensured by bringing the two images of one particular point of the object observed into alignment, and this can only be done when the two images of that point can be brought simultaneously very close to the dividing line.

If the images are seen as in Figs. 21 and 22, it would be difficult to detect a small error of coincidence, and the difficulty would be increased if the object observed were of irregular shape.

Fig. 23 shows the appearance of the images of a bell tent when the height of image is not correct, and it is obvious that very different ranges would be given if coincidence were made on the right or left side of the tent; one would be too long and the other too short.

The correct range will be shown if the lower image is exactly midway between the edges of the upper image, or if the range-finder is tilted until the dividing line is at right angles to one edge of the tent (see

Fig. 24), and coincidence is made on that edge. The same range will be obtained if the range-finder is tilted in the opposite direction and coincidence made on the other side of the tent.

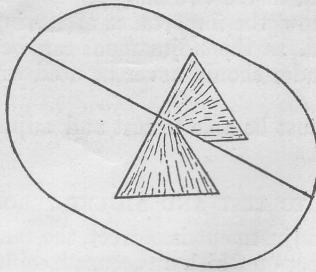


Fig. 24.

Again, Fig. 25 shows the images of a sloping post as they would be seen if the range-finder were held horizontal and the height of image were not correct. Here correct alignment has been obtained. The range scale is showing the correct range; but if the range-finder is depressed so as to bring the images together, they would appear as in Fig. 26 and would seem to be out of coincidence. If, however, the range-finder is tilted so that the dividing line is at right angles to the post, the images would appear as in Fig. 27, and the coincidence would be seen to be correct though the height of image is incorrect.

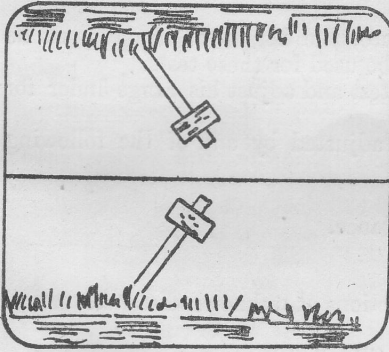


Fig. 25.

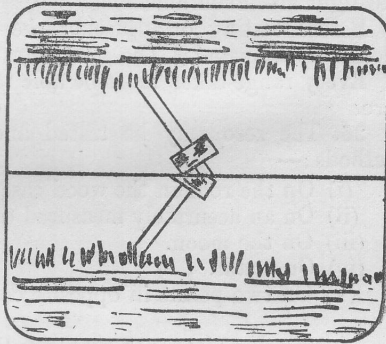


Fig. 26.

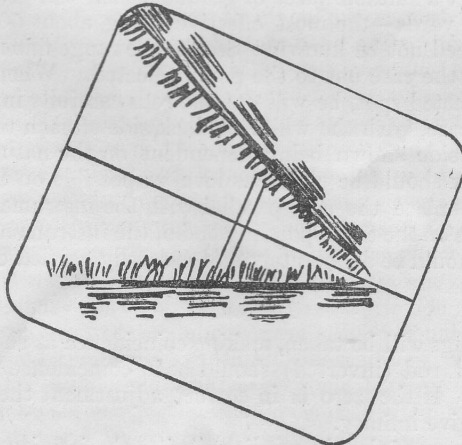


Fig. 27.

The *apparent* error of coincidence in Fig. 26 is due to the fact that, owing to the height of image being incorrect, the dividing line is cutting different parts of the post in the two images.

The above cases show the importance of having the height of image adjustment correct, and, as the adjustment can be so easily and quickly carried out, the range-finder should never be used with the height of image incorrect.

Every range-taker must be able to test and adjust the height of image of his range-finder.

4. TO TEST AND ADJUST ZERO.

25. When the zero adjustment is correct, the range scale will show the correct range of any object on which an accurate coincidence has been made.

If the scale gives a reading which is not the true range, then the zero is incorrect and must be adjusted.

An incorrect zero is caused by a derangement of the inner frame, or of the lenses or prisms mounted in it. A jar or a blow may cause this derangement.

The range-finder is so constructed that the zero, once set, is not likely to go wrong in the course of ordinary use. But it is nevertheless necessary to test the zero before using the range-finder in order to be certain of its accuracy.

An alteration of the zero adjustment should only be undertaken with deliberation and care, and as far as possible when the conditions of weather and light are favourable.

Before testing or adjusting the zero, the height of image must be accurately adjusted. The stand must be used for these tests.

Every range-taker must be able to test and adjust his range-finder for zero.

26. The zero may be tested and adjusted by any of the following methods:—

- (i) On the rods in the wood case.
- (ii) On an accurately measured distance.
- (iii) On the moon.
- (iv) On a star.
- (v) On two points in opposite directions at unknown distance.

(i) ON THE RODS IN THE WOOD CASE.

27. First select a suitable piece of ground which will give a distance of not less than 300 yards—the most effective being about 500 yards. The actual distance need not be known. Set up the range-finder on the stand. Send a man with the case out to the point selected. When the man has arrived at the selected spot, he will put the rods carefully into their sockets in the lid of the case, with the white or black side of each rod towards the range-finder, the side shown being dependent on the nature of the background. The box should be placed as level as possible on the ground.

He will then place the case parallel with the instrument by aligning one end of the case on the corresponding end of the instrument (see Fig. 28). This alignment should be deliberately and carefully carried out.

To Test.

28. Six readings will be taken, making coincidence as shown in Fig. 30, *i.e.*, the left-hand rod (inverted) should be in coincidence with the right-hand rod (erect). If the zero is in correct adjustment the mean of these readings should give infinity.

Should the mean of the six readings bring the infinity mark to one of

the following parts of the reader—the apex, half-way between the apex and one of the angles at the base, or one of the base angles (see Fig. 31)—note the part and take subsequent readings from it. If, on the other hand, the mean of the readings brings the infinity mark above or below the reader, the instrument must be adjusted.

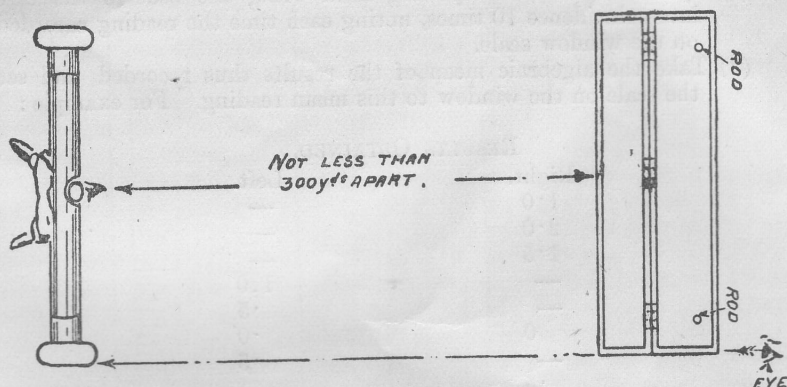


Fig. 28.

It must now be noted whether the instrument is reading over or under.

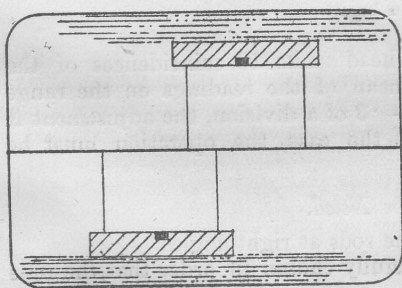


Fig. 29.

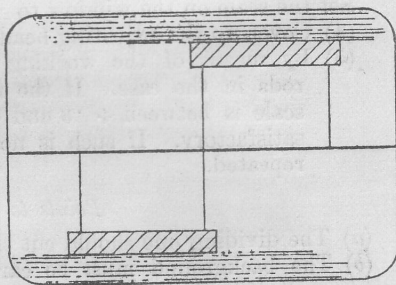


Fig. 30.

To Adjust the Zero.

Place the range scale at infinity, and examine the position of the two images as a guide as to how much the adjusting head must be turned to effect coincidence. Uncover the zero adjusting head by rotating the ring. The direction in which the head has to be turned for a range-finder reading over or under is shown on the plate adjacent to the head. The adjusting head should be turned until a perfect coincidence is obtained.

After the adjustment is made, cover the adjusting head by rotating the ring, and test the adjustment by taking six readings, the mean of which should bring the infinity mark opposite some portion of the reader (see above); if the mean brings the infinity mark still outside the reader, a further adjustment will be necessary.

Alternative Method of Adjusting the Zero with the Mark III Range-Finder.

The scale engraved around the left window (see p. 14) may be used as follows:—

- (1) Set the range scale to infinity.
- (2) By means of the adjusting head bring the rods in the case into coincidence 10 times, noting each time the reading recorded on the window scale.
- (3) Take the algebraic mean of the results thus recorded and set the scale on the window to this mean reading. For example:

RESULTS OBTAINED.	
Right.	Left.
1.0	—
2.0	—
1.5	—
—	1.0
—	.5
0	.0
—	.5
.5	—
1.0	—
0	0
<hr/>	
6.0 Right.	2.0 Left.

The mean reading is $\frac{6 \text{ right} - 2 \text{ left}}{10}$ or .4 right.

Set the scale on the window to .4 right.

- (4) Cover up the adjusting head.
- (5) By means of the working head make 10 coincidences of the rods in the case. If the mean of the readings on the range scale is between + .3 and - .3 of a division, the adjustment is satisfactory. If such is not the case, the operation must be repeated.

Points to be Noted.

- (a) The dividing line should cut the rods at right angles.
- (b) The background must be carefully chosen in order that the rods may be well defined.
- (c) When adjusting, the range-taker should not observe while turning the adjusting head.
- (d) In order to avoid possible errors due to the rods not being exactly parallel, coincidence should be made low on the rods, as low down as possible.

(ii) ON AN ACCURATELY MEASURED DISTANCE.

29. This is possibly the most practical method in peace, but an accurately known distance is essential. Rifle ranges are not always sufficiently accurate, and therefore must be used with caution. The distance should be as long as possible, consistent with atmospheric and other conditions; 800 yards may be taken as the minimum.

To Test.

30. Having selected a suitable object to which the correct distance has been ascertained, take six readings. If the mean of the six readings

enables the correct range to be read from the reader, as described in para. 28, read from that point (see Fig. 32, where the true range is 1,000 yards, and the point from which readings should be taken is half-way up the upper side of the reader.)

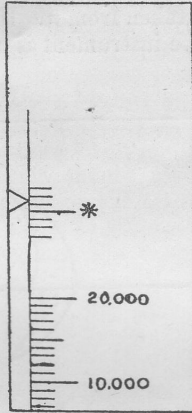


Fig. 31.
(Infinity mark opposite
the lower base angle of
the reader.)

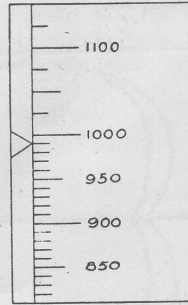


Fig. 32.

If, however, the reader cannot be used, note whether the range-finder is reading over or under the correct distance.

To Adjust.

31. Place the scale at the correct range and make coincidence of the object by means of the adjusting head, by turning it in the required direction according to whether the range-finder is reading over or under; then test the accuracy of the adjustment by taking six readings.

The alternative method described on page 28 may be used, the range scale being set to the accurately measured distance instead of to infinity.

(iii) ON THE MOON.

To Test.

32. Get the two images of the moon in the field. Carefully focus the eyepiece. Then rotate the range-finder downwards, so that the two images merge into one another till the dividing line is seen to be cutting them diametrically (see Figs. 33A and 33B). It should be remembered that unless the dividing line cuts the moon diametrically, coincidence will be

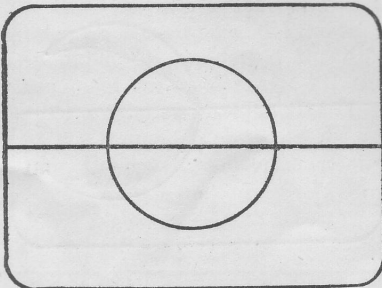


Fig. 33A.

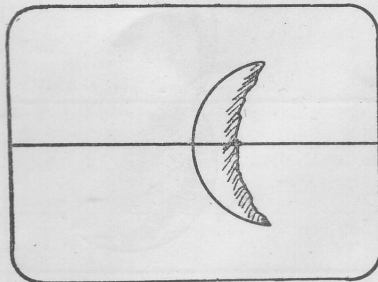


Fig. 33B.

difficult to make (see Fig. 33C), and an error in the height of image (see Fig. 33D), if present, will make the test valueless.

Take six readings; the mean of these should give the infinity mark opposite the apex of the reader. If this is not so, but one of the alternative parts of the reader (see para. 28) is observed to be opposite the infinity mark, this point should be noted and readings taken from it. If the infinity mark lies outside the reader, note whether the instrument is reading over or under, and adjust.

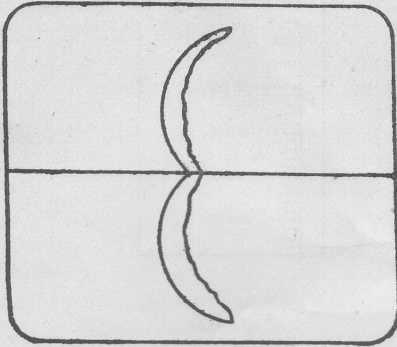


Fig. 33C.

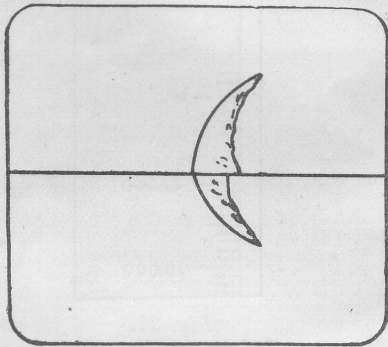


Fig. 33D.

To Adjust.

33. Set the scale at infinity, and adjust with the adjusting head as already described when adjusting on the rods.

Points to be Noted.

(a) This method of testing the zero is difficult, and is quite unreliable unless the range-taker has had considerable practice in it. As, however, it has certain advantages it should not be neglected.

(b) If the moon is sufficiently clearly defined, it may sometimes be possible to make coincidence on the extremities of the images. (Figs. 34A, 34B).

(c) If the time permits, the height of image should be tested and, if necessary, adjusted, on the moon previous to testing the zero.

(d) If the moon is high in the sky this test cannot be carried out, owing to the inability to use the stand.

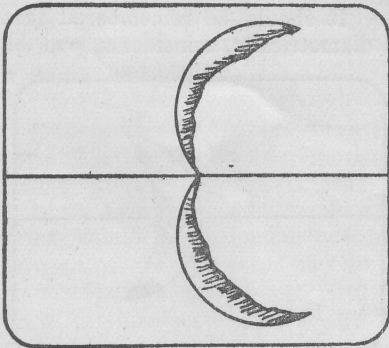


Fig. 34A.

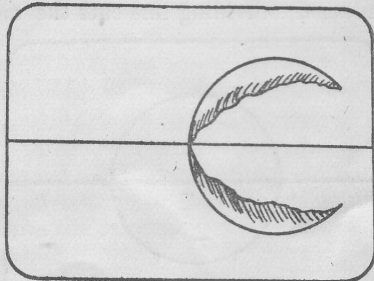


Fig. 34B.

(iv) ON A STAR.

34. The range-finder can be tested and adjusted on a star, with or without the astigmatic glasses. Putting the latter in or out of action should not make any difference to a coincidence. If any difference is apparent, the astigmatic glasses should not be used until they have been readjusted by an expert.

To Test.

35. (a) *Using the astigmatic glasses—*

Pick up a star near the horizon in the field of view. Press forward the astigmatiser lever, and focus the eyepiece. Take six readings, the mean of which should read infinity, or the infinity mark should come opposite a point on the reader as explained in (i) and (iii) tests.

(b) *Not using the astigmatic glasses—*

As above, but the image of the star will appear as a point, not a line.

To Adjust.

36. As on the moon.

Points to be Noted.

(a) A very accurate focus must be obtained, and the focus when using the astigmatic glasses will differ from that when the glasses are not in use with the Marks I and II instrument.

(b) The height of image must be examined and, if necessary, corrected, before carrying out the test. This must be done without using the astigmatic glasses.

(c) An isolated star should be selected to avoid the danger of joining up the images of two stars which lie close together. As any star will give a correct result, the one originally selected need not be adhered to throughout the test.

Range-takers should be carefully trained in the adjustments on moon and star, and should be practised as much as possible.

(v) ON TWO POINTS IN OPPOSITE DIRECTIONS AT UNKNOWN DISTANCE.

To Test.

37. Select a moderately level piece of ground, with a clear field of view, of a length not under 600 yards in extent, *i.e.*, rather more than double the lowest range which can be read on the scale. Set up the range-finder in the middle, send a man out approximately, but not less than, 300 yards from the range-finder to place a rod in the ground.

Send another man out in the opposite direction to as nearly as possible a distance equal to that taken by the first man. He also places a rod in the ground exactly in alignment with the range-finder and the other rod.

Take the range OA, which reads, say, 515 yards. Swing the range-finder on the stand and take the range OB, which reads, say, 518 yards. (Should it be found that the difference between OA and OB is greater than $\frac{1}{10}$ of the total range AB, the instrument should be moved.) Take the range-finder up, and after marking the point O, go to A or B, say B. Set the range-finder up at B, and take the range BA; if it reads 1,033 yards, the instrument is correct. Suppose it reads 1,060 yards then add

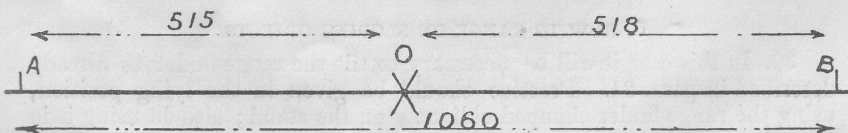


Fig. 35.

the distances OA and OB together; this gives 1,033; multiply this by 2, which gives 2,066; subtract the range recorded from A to B, *i.e.*, 1,060; the difference—1,006 yards—is the correct range.

To Adjust.

The correct distance having now been ascertained, *i.e.*, 1,006 yards, the adjustment is carried out as in method (ii), p. 28, already described.

It is not necessary to employ two men if suitable objects can be found which lie not less than 600 yards apart. In this case the range-finder will be placed as nearly as possible half-way between the objects, and on the line joining them, the test being carried out as above.

It is important that the scale should be very carefully read and that very accurate coincidences are made.

The distance of 600 yards has been given as the minimum, but more accurate and reliable results will be obtained if a longer distance is available.

5. USE OF THE INSTRUMENT IN VARIOUS POSITIONS WITH AND WITHOUT THE AID OF THE STAND.

38. The stand should always be made use of to steady the range-finder if possible, but since it is evident that on active service it will not always be possible to range in the prone position, range-takers should be taught to range with the range-finder in all positions other than lying. The stand should, however, always be kept attached to the range-finder. The method of instruction should be the illustration of the position and manner of holding the range-finder by the instructor, to be followed by imitation on the part of the range-taker under instruction.

The chief difficulty will be found in holding the range-finder so steady that the images touch the dividing line, and do not disappear at it. This difficulty is especially evident when the working head is revolved. The most steady and easiest position, according to the build of the individual, should be adopted.

The right handle must be held with the right hand so that the forefinger is in the proper relation to the working head, but the left hand may hold the range-finder by the left handle (see Plate VI), or it may encircle the range-finder anywhere adjacent to the handle.

Easy objects within 800 yards should be selected.

The following positions will be taught:—Lying, kneeling, sitting, and standing.

In the lying position without the stand, both elbows or forearms should rest on the ground according to the height from the ground it is required to hold the range-finder (see Plate VII).

In the kneeling position, either the elbow or the stand may rest on the knee (see Plate VIII).

In the sitting position, the elbows may be rested on the knees, or the open stand on the left knee and the right elbow on the right knee (see Plate IX).

In the standing position the stand can be used with two of its legs extended and resting on the chest of the range-taker (see Plate X).

6. HOW TO RANGE ON SLOPING OBJECTS.

39. In this case it will be necessary to tilt the range-finder as already described in para. 24. Practice should be given in the lying position, using the range-finder clamped obliquely on the stand; also in using it in the other positions.

7. USE OF GROUND AND COVER.

40. By the selection of a suitable piece of ground and the provision of cover, instruction can be afforded in adopting suitable positions. The use of folds in the ground, how to use trees, walls, trenches, &c., should be taught (see Plates XI and XII). Whenever possible, the range-finder should be rested when the stand cannot be used (see Plate XI). When using cover, the first essential is to hold the range-finder so as to obtain the greatest accuracy and rapidity in ranging; cover as a means of protection should be a secondary consideration.

CHAPTER IV.—ADVANCED STAGE.

41. In this stage the conditions and requirements of active service will be simulated. Rapidity in range taking must be increased by the introduction of a time limit.

Care and practice is necessary to ensure that rapidity combined with accuracy is constantly maintained.

Instruction should be afforded on ground of varying character.

Positions must be adopted which are suitable to the ground and cover available.

Practice should be afforded in taking ranges up to 2,000 yards.

42. Objects selected for long range taking will be chosen so that they become progressively more difficult, and approximate more nearly to service conditions. On service an enemy will generally avoid the vicinity of good ranging marks, and therefore range-takers should be afforded practice in ranging upon objects not actually on the position to which the range is required.

A practical method is to select an object upon which it is possible to range with the range-finder, lay a rifle from an aiming rest upon a possible fire position in the vicinity of the object selected, then tell the range-taker that the range is required to the fire position upon which the rifle is laid, but without referring to the object selected. The range-taker, having looked along the rifle, will be required to obtain the range to the position indicated. Considerable practice is necessary, particularly in undulating country, to recognize when an object to which the range is taken is not actually on the same feature as the position to which the range is required. When such an object is selected, as being the only one available, the necessary deductions or additions should be made before giving in the range.

43. The preparation of range cards (see Fig. 36), particularly for defensive purposes, taking ranges to prominent objects to serve as key ranges in the attack, and description of objects in writing, require frequent practice.

As the range-finder, owing to its high power and clear view, acts as an effective telescope, the range-taker should be thoroughly trained to correctly observe fire and movement, to pick up difficult service targets, and to describe them both verbally and in writing.

Ranging on a Moving Object.

44. There are various ways of dealing with a moving object, viz. :—

- (i) Obtaining and maintaining coincidence on the moving object, at the same time calling out the ranges.
- (ii) Making coincidence on the object, read the scale, and if the object is advancing, set the scale lower according to the rate of movement of the target, calling out that range for the setting of

sights. The range-taker will then observe the object, and just before the latter reaches the range at which the scale is set and the sights are adjusted, he will inform the fire unit commander, who will immediately open fire.

- (iii) In another method—perhaps the most satisfactory—the range-taker will not range on the moving object, but on some point on the ground over which the object will pass. The commander will be informed of this range, and when the range-taker observes that the moving object is about to reach the point ranged on, he will inform the commander.

Irrespective of the method employed, the range-taker should remain in observation when fire has been opened, to assist in correcting the sighting elevation.

Astigmatic Glasses.

45. The astigmatic glasses afford a means of ranging on illuminated objects both by day and night. The glasses draw out a point of light into a vertical line, the smaller the light the thinner will be the vertical line.

The eyepiece, for night work, must be focussed on the vertical line.

By night, with the aid of the glasses, the range can be obtained to a light, *e.g.*, to a signaller's lamp, a light in a window, &c.

By day it is possible to range on small well-illuminated objects, *e.g.*, on a piece of glass reflecting the sun's rays, on a heliograph, &c.

To use the glasses, with the thumb of left hand press forward the astigmatic lever, and maintain pressure on the lever with the Marks I and II, but not with the Mark III.

Ranging in Mirage.

46. Owing to the high telescopic power of the range-finder, it is difficult to obtain a correct range to an object in mirage without much practice. The two images of the object do not appear to vibrate together, for while the inverted image appears to be vibrating to the right, the erect image may appear to be vibrating to the left. The amount of vibration also varies, and, to obtain reliable readings, it is necessary not only to move the erect image into coincidence from opposite directions, but also to make the coincidence in such a way that one image appears to vibrate through the same distance on both sides of the other image.

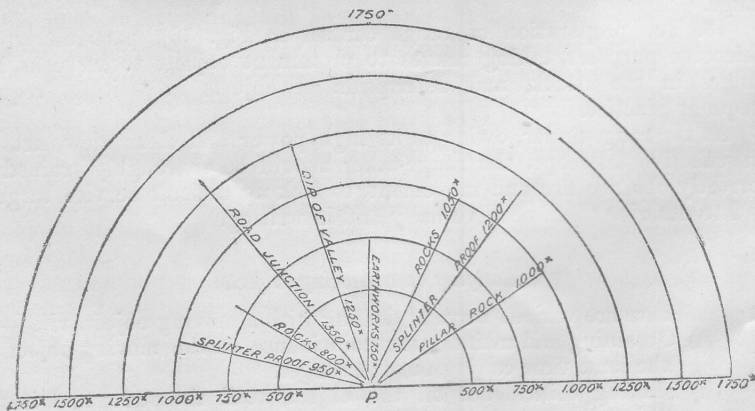


Fig. 36.

When there is a mirage the range-taker should endeavour to get above the ground—on a cart or haystack—then he will find his difficulties lessened.

RANGE CARD FOR USE IN ATTACK.

0	FIRST OBJECTIVE—FARM.	
500	RAILWAY.	
900	TWIN TREES.	
1,400	CANAL.	

Ranging in Rain.

47. Ranging is impossible should rain get on to the end windows. When rain is blowing from the front, and the ray shades do not protect the windows, the range-taker must either get inside a building or arrange for some sort of shelter to be held over him. Rain coming from any direction but the front will not generally interfere with ranging.

TACTICAL EXERCISES.

48. The object of a tactical exercise is to train range-takers in the practical use of their range-finders by working out on the ground a simple tactical situation designed to exemplify some of the conditions under which they might be required to use their range-finders on service.

49. In order that a range-taker may be of assistance to his commander in the field, he should be acquainted with the principles of tactics, so that he can grasp the requirements of a situation from the range-taking point of view.

He should also be taught to study ground to obtain an eye for country in order that he may recognize objects and features, the ranges to which may be required. While working across country, he should be exercised in ranging from various kinds of ground, sloping up or down, and in learning to adopt at once the most suitable position, which will give the greatest steadiness without unduly sacrificing rapidity. He should also be instructed in observing and ranging from cover, making use of natural objects to support the range-finder when the stand cannot be used. Practice can also be given in selecting suitable objects upon which to range; they should be selected in accordance with the tactical requirements, and should be such as will be of military value. Description of objects, both verbally and in writing, should also be practised, attention being drawn to the importance of clearness and conciseness. The instructor should discuss and criticise fully the various points as they arise. The preparation of range cards and the taking of key ranges should be included. These exercises should be frequently carried out. At first, they should be quite simple, becoming gradually more difficult, the ground being varied as much as possible. The study of ground and description of objects should begin in the earliest stages without instruments, which should not

be taken out until the advanced stage (see para. 41) has been reached. A tactical exercise may suitably be carried out as a test before the range-taker is allowed to join his company as efficient.

ELEMENTARY INSTRUCTION IN A CONFINED SPACE.

50. Elementary instruction can be carried out on a barrack square or in a drill hall or gymnasium, if the light is sufficiently good, or from a barrack room window, the method being resorted to under adverse weather conditions, or when circumstances do not allow ranging marks at a distance of 250 yards or over to be obtained.

It is possible to teach accurate coincidence, reading of the scale, the various positions and use of artificial cover, as well as the use of the range-finder both horizontally and vertically.

51. To carry out this method, place two similar objects at a distance of not less than 25 yards from the instrument. The distance between these objects must not be less than 2 feet $4\frac{1}{2}$ inches, and should not be more than just less than the optical base of the range-finder.

Lines ruled on a white board or the rods from the case are suitable, and for more advanced work, two similar landscape targets may be used.

It is important that the similar objects should be absolutely parallel.

52. The objects should not be at a less distance than 25 yards from the range-finder, because at a shorter distance it is impossible to obtain a sufficiently good focus. It is necessary to focus the images and not the dividing line if the objects are under 100 yards. The objects should not be closer together than 2 feet $4\frac{1}{2}$ inches as otherwise a coincidence cannot be obtained. It is important when checking coincidences that exactly the same hold is kept on the range-finder, as the slightest tilt will affect the coincidence.

FIELD SKETCHING.

53. This instrument will be found very useful on reconnaissance. It is quite easy to carry either mounted or dismounted.

To rapidly survey a position or plot of ground, take a flat board, or, preferably, a plane table, FGH, Fig. 37.

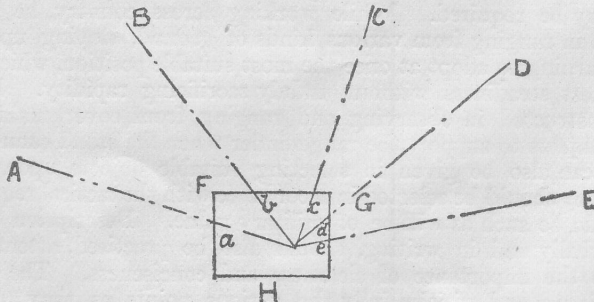


Fig. 37.

Select salient points, such as A, B, C, D, E, draw lines AH, BH, &c., and take the ranges of AH, BH, &c., and mark these distances on the

scale employed in the lines AH, BH, &c. As each range ought not to take more than half a minute, a rapid and accurate survey can thus be made in a short time.

From the above it will be seen that the relative distances of various points can be ascertained without occupying them.

Hedges, roads, &c., have in this way been plotted, and an accurate survey made.

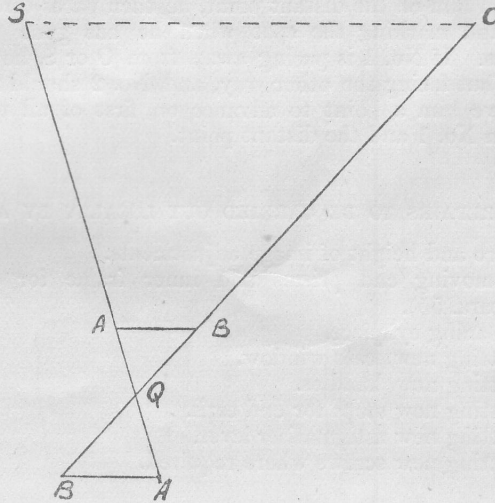


Fig. 38.

TO FIND THE DISTANCE BETWEEN TWO INACCESSIBLE POINTS.

Fig. 38 shows how the distance between any two objects may readily be determined.

Let S and O be any two points the distance between which it is required to ascertain. The ranges of S and O are taken from any point Q.

Lay out QA, QB in the same lines as QS, QO; make QA a convenient proportion of QS and QB the same proportion of QO.

Measure AB, which will bear the same ratio to OS.

Example :—

Let $QO = 2,500$ yards.

$QS = 2,000$ „

Make $QB = \frac{QO}{100} = 25$ yards.

$QA = \frac{QS}{100} = 20$ „

Measure AB; suppose it is 21 yards.

Then $21 \times 100 = 2,100$ yards is the distance between S and O.

In practice, one man should pace the distance QB, and, having marked the point B, should pace the distance QA and then the distance AB. No two men pace alike.

To keep the exact line is very important. The length of the pace is of no consequence, provided it is uniform. For greater accuracy it is as well to pace the lines twice (once each way).

Calculation may be avoided thus :—

No. 1 when pacing QB, QA will take two paces for every hundred yards, and then, when pacing AB, count a hundred yards for every second pace, and so obtain AB at once in hundreds of yards, an odd pace being 50 yards.

No. 2 should assist in keeping correct line. If No. 1 is pacing towards O or S, he should stand at Q, and send No. 2 out towards the point he intends to advance on, and rather beyond B or A. Having carefully aligned him on the distant point, he then paces directly towards him, halting and marking the spot when he has gone the requisite number of paces. If No. 1 is pacing away from O or S, he should stand at Q as before, but facing the other way, and No. 2 should run out some distance and give him a point to advance on, first of all taking care to align himself on No. 1 and the distant point.

54. LIST OF REPAIRS TO BE CARRIED OUT LOCALLY BY ARMOURERS.

1. Zero and height of image adjustments.
2. Removing end prisms and inner frame for cleaning (see para. 55).
3. Cleaning eyepiece.
4. Fitting new scale window.
5. Fitting new handles.
6. Fitting new stops for end caps.
7. Fitting new astigmatiser lever.
8. Fitting new screws where required.

Stand.

1. Fitting a new leg to stand.
2. Fitting clamping bolt, with collar and keep screw.
3. Fitting screws as required.

It must be understood that only the repairs mentioned above are allowed to be carried out by an armourer, who must have qualified in small repairs at Woolwich. Should an instrument require attention in any other respect it must be sent to the Ordnance Department. A fully qualified officer must supervise any repair carried out by the armourer.

To Dismantle the Mark III Range-finder.

Plate IV.

55. The instrument should not be dismantled more often than is absolutely necessary for cleaning purposes. The work should be performed indoors or in a tent, and care must be taken that the various parts are perfectly clean and dry before the instrument is re-assembled.

The instrument must not on any account be dismantled by anyone unless he is in possession of a certificate stating that he is competent to do so. Great care must be exercised in taking the instrument to pieces and putting it together again. No force must be used. All the parts go together easily when correctly manipulated, and no force is necessary. If the parts do not slide into position easily it is due to their not being correctly brought together; and a little manipulation, turning or tilting the parts, will make them go together.

(1) To Remove an End Cap.

Remove the screw which prevents the complete revolution of the revolving ring. Turn the revolving ring until the rayshade is in its farthest position from the end window. Through the rayshade will then be seen a small sliding block or locking piece (14) which engages in a slot in the end cap. Remove the screw 14A* which secures the block, and slide the block away from the end cap. Unscrew the end cap.

The revolving ring can now be removed if it requires lubricating, but it need not be removed before taking the end prism or inner frame out of the range-finder.

(2) To Remove an End Prism.

The best method is to apply a thin screwdriver or a bent tommy in one of the small holes in the prism mount as shown in Fig. 39, and lever the prism out. This must be done with great care and with a finger pressed against the mount as shown. When the prism once starts moving it comes out very easily.

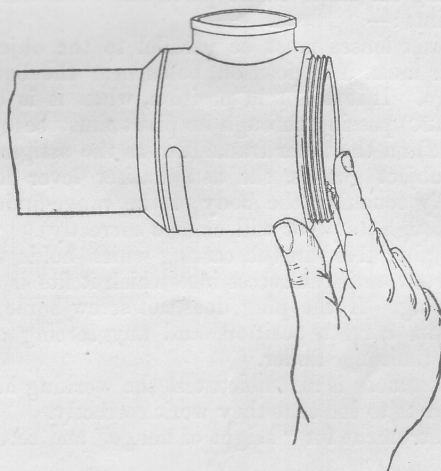


FIG. 39.

Another method is to pass a string through the two small holes in the prism mount and to pull on the string, but there is more risk of the prism coming out with a jerk and being dropped.

(3) To Remove the Inner Frame.

This can be removed from the right-hand end of the range-finder only.

Remove the right end cap and prism.

Loosen but do not remove the two screws (11A) which pass through the plate beneath the working head, and turn the plate through 90°; the plate and working head (11) can then be lifted out.

Fold back the right handle (10) and remove the screw plug (10A), which is visible at the bottom of the hole in the ring to which the handle is hinged.

Press the astigmatiser lever (12) towards the body of the range-finder,

* In some instruments this screw is removed through a small hole in the revolving ring instead of through the rayshade.

so that the lever (22) on the inner frame will not foul anything when the inner frame is being withdrawn.

Although it is not necessary to remove the astigmatism lever mechanism when removing or replacing the inner frame, it is advisable to do so. To do so, remove the small screw (12A) and screw plug (12B) from the casting in which the astigmatism lever is pivoted, and also a screw (12C) (beneath the plug) which passes through the lever pivot. The lever can then be withdrawn.

It is also often advisable to unscrew the front range scale window (9), so that the inner frame can be guided by a finger passed through the opening.

Turn the instrument so that the handles are downwards, and the right end slightly lower than the left, and allow the inner frame to start sliding out. When it has moved a short distance it must be turned through about quarter of a circle to allow of a projection on it passing another one on the inside of the tube. Let the frame slide completely out of the tube.

When replacing the inner frame particular attention must be paid to the following points:—

The astigmatism lenses must be parallel to the object glasses. The astigmatism lever must, if in position, be as near the body of the range-finder as it will go. If it is not in position, when it is being assembled, the long screw (12C) passing through its pivot must be engaged correctly with the lever (22) on the inner frame (*i.e.*, as the astigmatism lenses are parallel to the object glasses, the astigmatism lever must be inserted whilst it is nearly touching the body of the range-finder, and then the screw passing through its pivot will engage correctly).

The screwed plug (10A) in the casting which holds the right handle must not be inserted until the recess into which it fits is exactly opposite the hole for the plug. If the plug does not screw home easily, the inner frame is not in its correct position, and any forcing of the plug will seriously damage the range-finder.

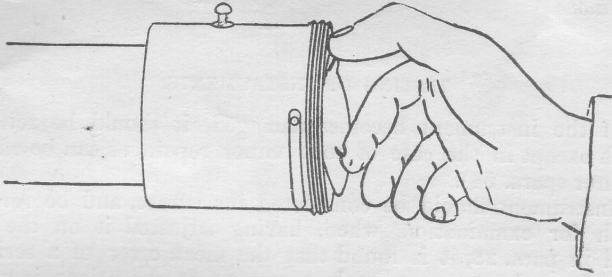
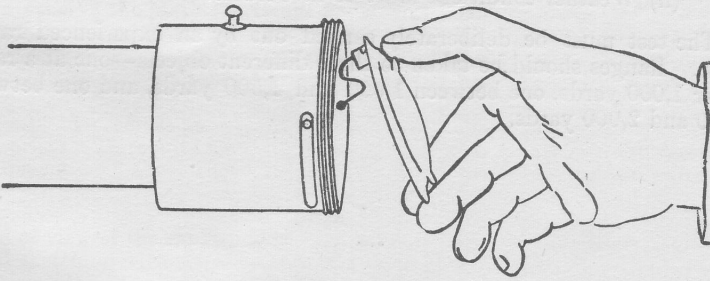
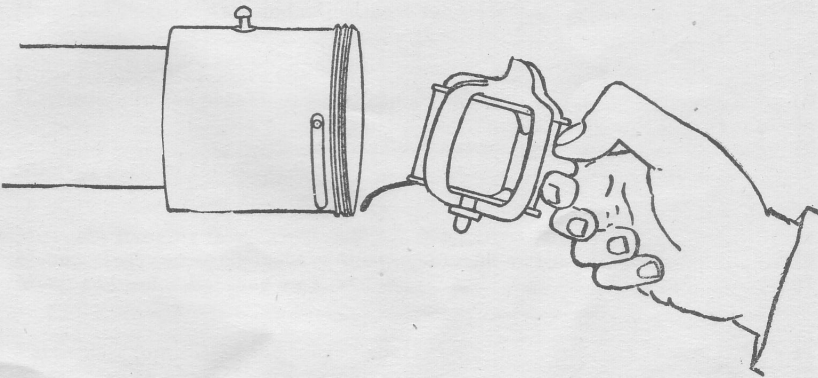
When the instrument is assembled test the working head, astigmatism lever and other parts to see that they work correctly.

Adjust the instrument for "height of image" and zero.

Marks I, I* and II.

These instruments are dismantled in a similar way to the Mark III with the following exceptions:—

- (1) *The locking piece which prevents the end cap from unscrewing is slightly differently arranged.*
- (2) *The end prism is mounted in a different way (see Figs. 39 to 41). To remove it proceed as follows:—*
 - (a) *Pull the lower end of the pentagonal prism retaining spring and plate outwards until it is clear of the tube (Fig. 39).*
 - (b) *Press the retaining spring and plate downwards, and pull them outwards until the catch at the top of the plate is free. Remove the end plate and spring (Fig. 40).*
 - (c) *Incline the top of the pentagonal prism holder outwards, and then lift it up slightly. It can then be removed (Fig. 41).*
- (3) *The arrangement, in the right handle, which supports the inner frame is differently arranged. First remove the small fixing screw in the side of the handle and the large screw which secures the right handle. Then remove the screw which supports the inner frame and which can be seen inside the handle.*

*Fig. 39**Fig. 40.**Fig. 41.*

- (4) *Before removing the inner frame the focussing lever of the right eyepiece must be pulled towards you, so that the eyepiece is drawn out as far as it will go.*
- (5) *The astigmatiser lever should not be pushed towards the tube, but be left alone.*

TESTING OF INSTRUMENTS.

56. If the instrument becomes damaged, it should be returned to Woolwich except in the case of such minor repairs as can be effected by an armourer (para. 54).

The instrument should be considered inaccurate, and be returned to Woolwich for examination, when, having adjusted it on the rods, as described in para. 28, it is found that the mean error of a series of 10 readings of any known range, taken under test conditions, is more than 5 per cent.

By "test conditions" is meant the conditions most favourable for accurate testing of the instrument, *i.e.* :—

- (i) The objects whose range is taken must be very clearly defined.
- (ii) Weather conditions must be favourable.

The test must be deliberately carried out by an experienced range-taker. Ranges should be taken to three different objects—one at a range under 1,000 yards, one between 1,000 and 1,500 yards, and one between 1,500 and 2,000 yards.

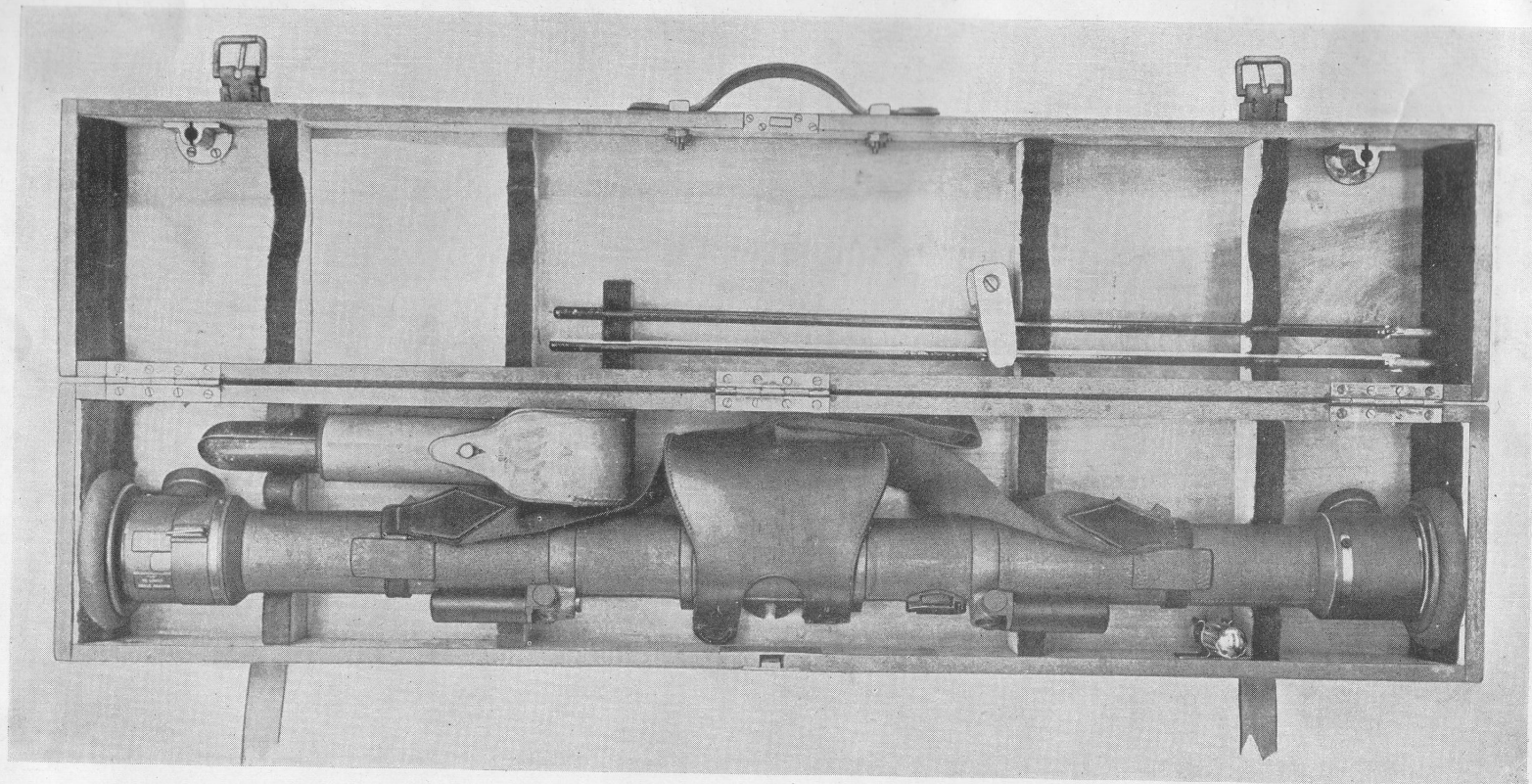
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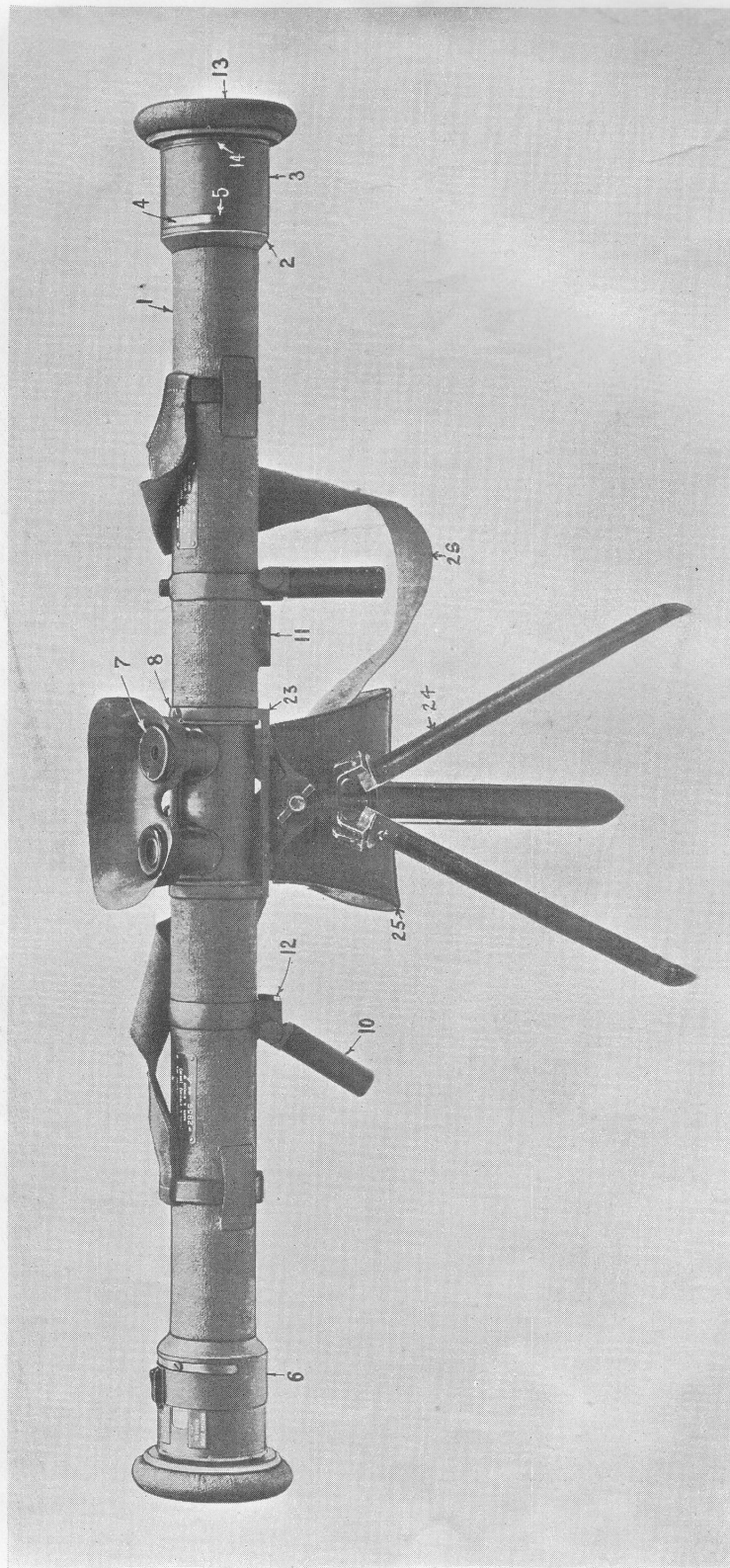
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PLATE I.



RANGE-FINDER, INFANTRY, No. 2.
(IN CASE.)

PLATE II.

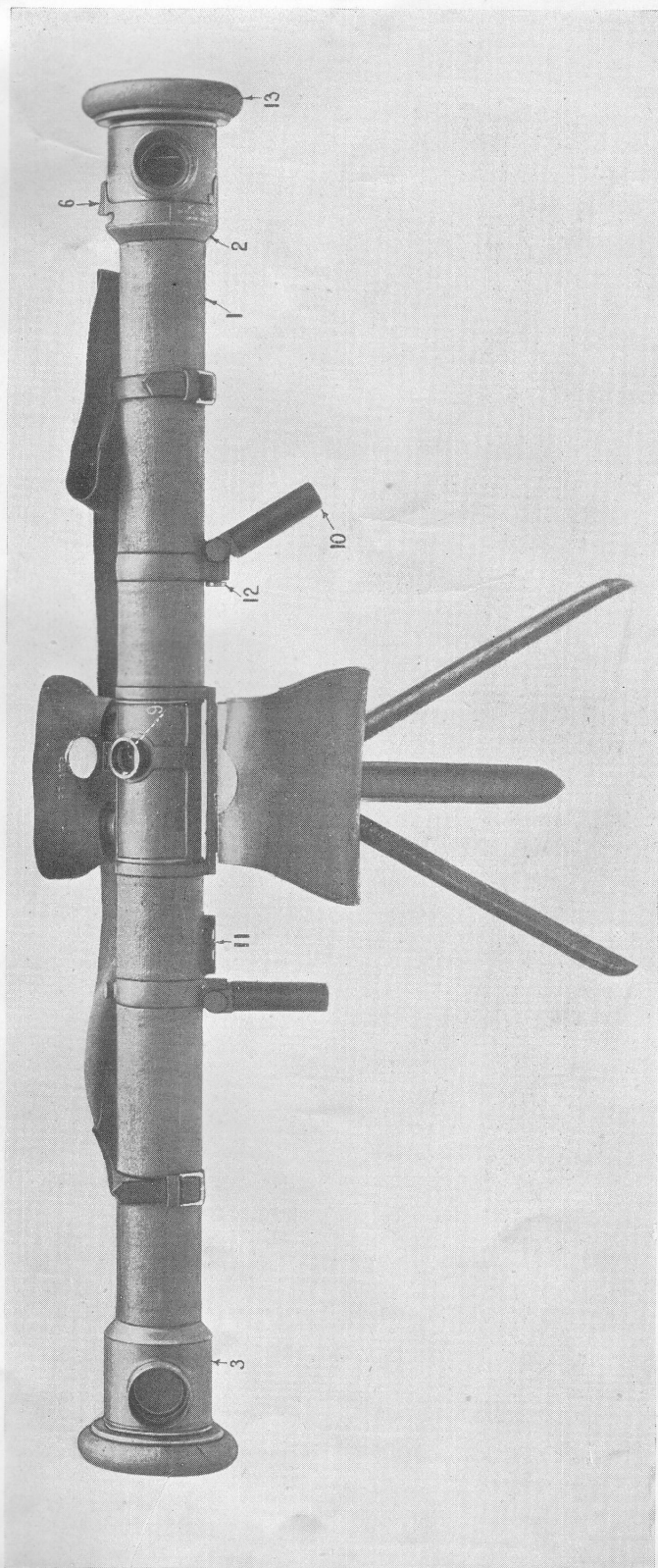


1. Outer tube.
2. End casting.
3. Revolving ring.

4. Slot in revolving ring.
5. Screw, limiting movement of revolving ring.
6. Ring, protecting adjusting heads.

7. Right eyepiece.
8. Focussing lever.
9. Front range scale window.

PLATE III.



10. Folding handle.
11. Working head.
12. Astigmatizer lever.

13. End cap.
14. Locking piece.
23. Carrier.

24. Stand.
25. Leather cover for protecting eyepieces.
26. Web sling.

PLATE V.



(B 12124)

PLATE VI.



PLATE VII.

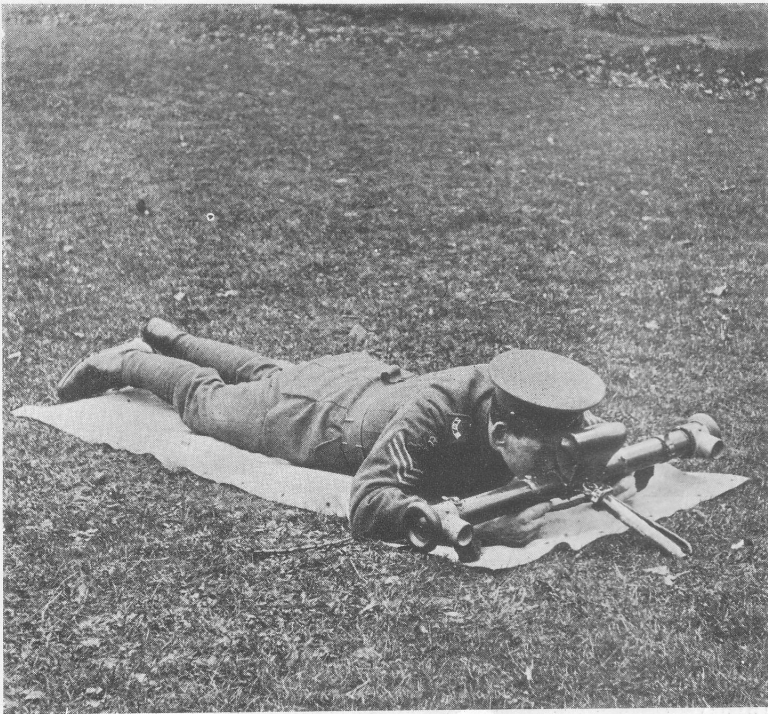


PLATE VIII.



PLATE IX.



PLATE X.



PLATE XI.

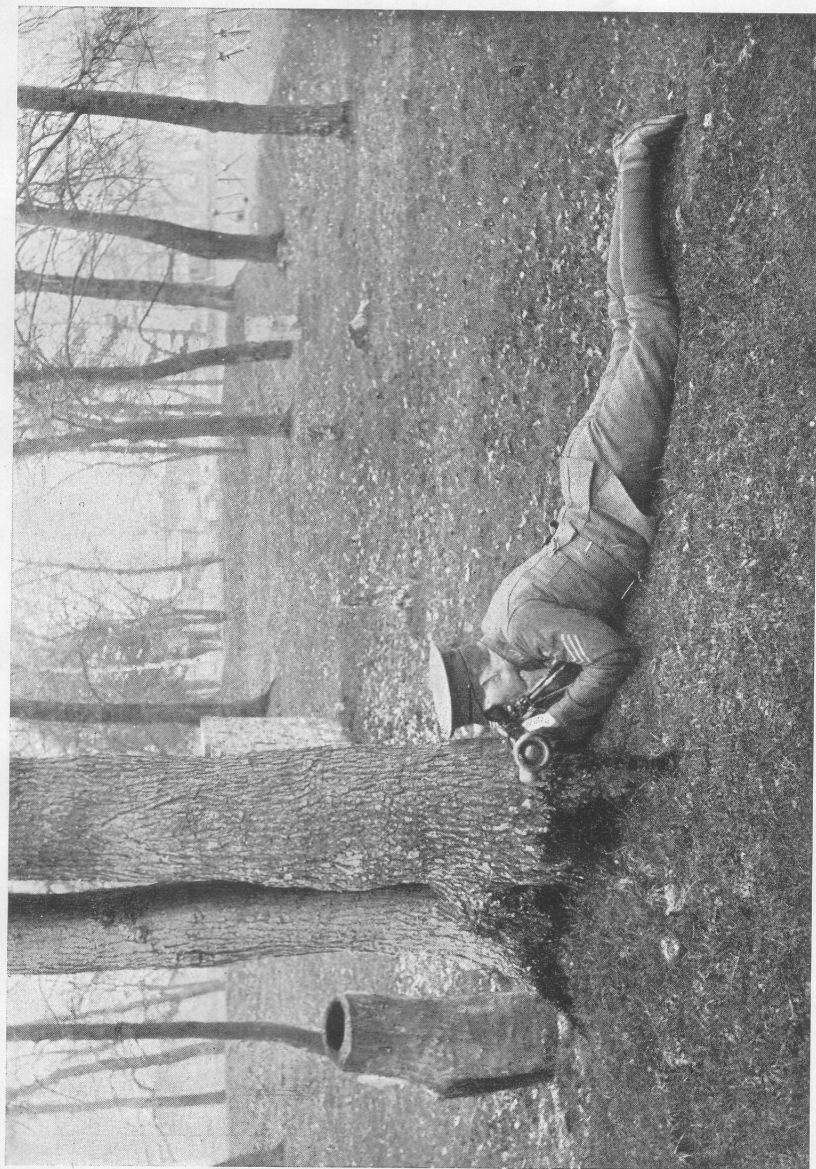


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